

This Page Is Inserted by IFW Operations
and is not a part of the Official Record

BEST AVAILABLE IMAGES

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images may include (but are not limited to):

- BLACK BORDERS
- TEXT CUT OFF AT TOP, BOTTOM OR SIDES
- FADED TEXT
- ILLEGIBLE TEXT
- SKEWED/SLANTED IMAGES
- COLORED PHOTOS
- BLACK OR VERY BLACK AND WHITE DARK PHOTOS
- GRAY SCALE DOCUMENTS

IMAGES ARE BEST AVAILABLE COPY.

**As rescanning documents *will not* correct images,
please do not report the images to the
Image Problem Mailbox.**



INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification ⁷ : H04L 9/00	A1	(11) International Publication Number: WO 00/57595 (43) International Publication Date: 28 September 2000 (28.09.00)
(21) International Application Number: PCT/SG99/00020 (22) International Filing Date: 22 March 1999 (22.03.99) (71) Applicant (for all designated States except US): KENT RIDGE DIGITAL LABS [SG/SG]; 21 Heng Mui Keng Terrace, Singapore 119613 (SG). (72) Inventors; and (75) Inventors/Applicants (for US only): BAO, Feng [CN/SG]; 37 West Coast Park, #04-06, Parkview Condo, Singapore 127653 (SG). DENG, Huijie, Robert [SG/SG]; 2 Namly Rise, Singapore 267110 (SG). (74) Agent: HELEN YEO & PARTNERS; 80 Raffles Place, #33-00 UOB Plaza 1, Singapore 048624 (SG).		(81) Designated States: JP, SG, US, European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE). Published <i>With international search report.</i> <i>Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i>
(54) Title: METHOD AND APPARATUS FOR ENCRYPTING AND DECRYPTING DATA		
(57) Abstract <p>A method and apparatus for encrypting and decrypting data is disclosed which employs two or more cryptographic algorithms to achieve high throughput without compromising security. The invention is especially useful for software implementation to protect large amounts of multimedia data over high-speed communication channels.</p> <pre> graph TD 100["Divide data into segments d1, d2, ..., di, ...; input shared key k and initial value v0; set i = 0."] --> 110["More data segment?"] 110 -- No --> Stop["Stop"] 110 -- Yes --> 120["i := i + 1; v1 := F(vi-1); s1 := R(k, v1); c1 := E(s1, di)"] 120 --> 130["Send c1"] 130 --> 110 </pre>		

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav Republic of Macedonia	TM	Turkmenistan
BF	Burkina Faso	GR	Greece	ML	Mali	TR	Turkey
BG	Bulgaria	HU	Hungary	MN	Mongolia	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MR	Mauritania	UA	Ukraine
BR	Brazil	IL	Israel	MW	Malawi	UG	Uganda
BY	Belarus	IS	Iceland	MX	Mexico	US	United States of America
CA	Canada	IT	Italy	NE	Niger	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NL	Netherlands	VN	Viet Nam
CG	Congo	KE	Kenya	NO	Norway	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NZ	New Zealand	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's Republic of Korea	PL	Poland		
CM	Cameroon	KR	Republic of Korea	PT	Portugal		
CN	China	KZ	Kazakhstan	RO	Romania		
CU	Cuba	LC	Saint Lucia	RU	Russian Federation		
CZ	Czech Republic	LI	Liechtenstein	SD	Sudan		
DE	Germany	LK	Sri Lanka	SE	Sweden		
DK	Denmark	LR	Liberia	SG	Singapore		
EE	Estonia						

METHOD AND APPARATUS FOR
ENCRYPTING AND DECRYPTING DATA

FIELD OF THE INVENTION

5

The present invention relates to cryptography and in particular to a method and apparatus for encrypting and decrypting digital data for the purpose of protecting or securing its contents.

10

BACKGROUND OF THE INVENTION

There exists a need to transfer data confidentially over an open channel or to store such data securely in an unsecure location. Whilst such transfer or storage may be achieved by physical means, it is more effective and/or flexible to use
15 cryptographic means.

In the prior art, to send private communications between two parties, the parties need to share a cryptographic key and use a symmetric-key cipher to encrypt and decrypt data. Various ciphers including block ciphers and stream ciphers have
20 been proposed in the past. A stream cipher handles messages of arbitrary size by ciphering individual elements, such as bits or bytes of data. This avoids the need to accumulate data into a block before ciphering as is necessary in a block cipher. A conventional block cipher requires an accumulation of a certain amount of data or multiple data elements for ciphering to complete. Examples of block
25 ciphers include DES (see ANSI X3.92, "American National Standard for Data Encryption Algorithm (DEA)," American National Standards Institute, 1981), IDEA (see X. Lai, J. Massey, and S. Murphy, "Markov ciphers and differential cryptanalysis," Advances in Cryptology - EUROCRYPT'91 Proceedings, Springer-Verlag, 1991, pp. 17-38), SAFER (see J. Massey, SAFER K-64: One
30 year later. In B. Preneel, editor, Fast Software Encryption - Proceedings of Second International Workshop, LNCS 1008, pages 212-241, Springer Verlag, 1995), and RC5 (see R. Rivest, "The RC5 encryption algorithm," Dr. Dobbs's Journal, Vol. 20, No. 1, January 1995, pp. 146 -148). A typical data encryption

-2-

speed for these ciphers is several million bits per second (Mb/s) on a Pentium 266 MHz processor.

5 Due to the pervasiveness of high-speed networking and multimedia communications, the demand for high-speed ciphers is ever increasing. For example, data rates over Asynchronous Data Transfer networks range from several tens of Mb/s to 1 Gb/s. Software implementations of existing block ciphers cannot reach these kinds of data rates.

10 In general, stream ciphers are much faster than block ciphers. However, stream ciphers are usually not sufficiently analyzed and are perceived to be weaker in security than block ciphers. Many stream ciphers that we believed to be very secure were subsequently broken. The design of secure and efficient high-speed ciphers remains a highly challenging problem.

15 Many powerful cryptanalytical methods have been developed during the past decade or so. It may be observed that the success of many of these methods in attacking a cipher depends on the availability of a large quantity of ciphertexts/plaintexts under a particular encryption key. Normally, the likelihood
20 of successfully attacking a cipher, i.e., discovering the key, diminishes as the amount of available ciphertexts/plaintexts decreases. The present invention, is motivated by the above observation, and provides an improved method and apparatus for data encryption and decryption.

25

SUMMARY OF THE INVENTION

The method of the present invention may employ a combination of at least two cryptographic algorithms to achieve relatively high throughput without compromising security. A first algorithm may be a cryptographic pseudo random
30 sequence (or number) generator with strong security, and a second algorithm may be a cipher capable of high-speed operation, but may be weak in security when used alone. The first algorithm may be used to systematically and periodically generate "segment keys" and the second algorithm may be used to encrypt a data segment or plaintext segment using a segment key. Each data

-3-

segment may be encrypted using a different segment key. By limiting the sizes of the data segments, an attacker may not have sufficient plaintexts or ciphertexts under a given segment key to carry out meaningful cryptanalysis against the second algorithm. In doing so, the present invention may achieve high throughput in data encryption and decryption without compromising overall security of the system.

According to one aspect of the present invention there is provided a method of encrypting data suitable for sending to a decrypting party, said method including the steps of:

- (a) dividing said data into data segments;
- (b) accepting at least a cryptographic key k shared with the decrypting party;
- (c) for the i th data segment ($i = 1, 2, \dots$), to be encrypted, generating the i th segment key s_i using a first function with said cryptographic key k and some accessory data strings as inputs;
- (d) encrypting the i th data segment using a second function with s_i as the encryption key to form the i th ciphertext segment; and
- (e) outputting the i th ciphertext segment, and at least a part of said accessory data strings for sending data to the decrypting party, and if more data segments are to be encrypted, repeating steps (c), (d) and (e).

The accessory data strings may include a single string v_i derived from the previous value v_{i-1} in a predetermined fashion. The string v_i may be derived according to the relation $v_i = F(v_{i-1})$, $i = 1, 2, \dots$, wherein $F()$ maps v_{i-1} to v_i and v_0 is an initialization value made known to the decrypting party.

According to a further aspect of the present invention there is provided a method of decrypting data encrypted by an encrypting party, said method including the steps of:

- (a) accepting at least a cryptographic key k being shared with the encrypting party;

-4-

- 5 (b) for the i th ciphertext segment ($i = 1, 2, \dots$) to be decrypted, generating the i th segment key s_i using a first function with said cryptographic key k and some accessory data strings as inputs;
- (c) decrypting the i th ciphertext segment using a second function with s_i as the decryption key;
- (d) outputting the decrypted i th ciphertext segment, and if more ciphertext segments are to be decrypted, repeating steps (b), (c) and (d).

10 According to a still further aspect of the present invention there is provided apparatus for encrypting data suitable for sending to a decrypting party, said apparatus including:

- 15 (a) means for dividing said data into data segments;
- (b) means for accepting at least a cryptographic key k shared with the decrypting party;
- (c) means for generating for the i th data segment ($i = 1, 2, \dots$) to be encrypted, the i th segment key s_i using a first function with said cryptographic key k and some accessory data strings as inputs;
- 20 (d) means for encrypting the i th data segment using a second function with s_i as the encryption key to form the i th ciphertext segment; and
- (e) means for outputting the i th ciphertext segment, and at least a part of said accessory data strings for sending data to the decrypting party.

25 According to a still further aspect of the present invention there is provided apparatus for decrypting data encrypted by an encrypting party, said apparatus including:

- (a) means for accepting at least a cryptographic key k being shared with the encrypting party;
- 30 (b) means for generating as inputs for the i th ciphertext segment ($i = 1, 2, \dots$) to be decrypted, the i th segment key s_i using a first function with said cryptographic key k and some accessory data strings;
- (c) means for decrypting the i th ciphertext segment using a second function with s_i as the decryption key; and

-5-

(d) means for outputting the decrypted i th ciphertext segment.

The apparatus of the present invention may be conveniently embodied by means of a suitably programmed general purpose digital computer. It is well within the capability of persons skilled in the art of programming digital computers to develop software programs for implementing the encrypting/decrypting methods described herein. Alternatively the apparatus may be implemented via dedicated hardware.

DESCRIPTION OF PREFERRED EMBODIMENT

A preferred embodiment of the present invention will now be described with reference to the accompanying drawings wherein:

FIGURE 1 depicts a flowchart of the operation of an illustrative embodiment of the present invention at the data encrypting end of a communication channel; and

FIGURE 2 depicts a flowchart of the operation of an illustrative embodiment of the present invention at the data decrypting end of a communication channel.

FIGURE 1 shows the operation of the present invention at the encrypting end of a communication channel. Data encryption is performed using two cryptographic algorithms, the first being a cryptographic pseudo random sequence generator $R()$ and the second being a high-speed cipher $E()$, which may be relatively weak in security when used alone. The pseudo random sequence generator accepts two inputs k and v and outputs a pseudo random sequence $s = R(k, v)$. The high-speed cipher accepts a secret key s and a data segment d and produces the ciphertext $c = E(s, d)$. In addition, the illustrative embodiment uses a pre-determined function $F()$ to update an initial value, i. e., $v_i = F(v_{i-1})$. It is assumed that the encrypting end and decrypting ends share a secret key k , an initial value v_0 , and the functions $F()$ and $R()$. Moreover, it is assumed that the decrypting end knows the decrypting algorithm $D()$ corresponding to the encrypting algorithm $E()$.

As shown in FIGURE 1, at step 100, a program at the encrypting end divides the data to be encrypted into segments of equal or unequal sizes: $d_1, d_2, \dots, d_i, \dots$. In

-6-

the former case the last segment may be padded with random data if necessary; while in the latter case, the sizes of the data segments normally need to be known by the decrypting end to facilitate decryption. Furthermore, the program accepts the shared secret key k and the shared initial value v_0 as inputs, and sets the
5 index $i = 0$.

At 110, the program inspects if there is any data segment available for encryption, and if not, the program terminates. Assuming that there is a data segment available, the program, at 120, increments the index i by 1, gets an updated initial
10 value $v_i = F(v_{i-1})$, generates a segment key $s_i = R(k, v_i)$, and uses the segment key to encrypt the data segment to get the ciphertext segment $c_i = E(s_i, d_i)$ in a manner that is well known to those skilled in the art.

At 130, the program transmits the ciphertext segment, and optionally the size of
15 the corresponding data segment, to the decrypting end. The program then goes back to 110 to see if more data segments need to be encrypted. If so, the preceding process is repeated.

The function $F()$ is used to update the initial value. One example is $v_i = v_{i-1} + 1$
20 and another example is a cryptographic hash function.

Those skilled in the art will see that the shared secret key is protected by the cryptographic pseudo random generator $R(k, v_i)$. To obtain good security, it is required that $R()$ be secure against all known attacks to the key k . $R()$ is
25 preferably a secure one-way function or one-way hash function in k . That is, given $R(k, v_i)$ and v_i , it should be computationally hard to find k . One example of a pseudo random generator is a keyed one-way hash function $h(k, v_i)$ or $h(k, p, v_i, k)$ where $h()$ is a one-way hash function and where p pads k to a full input block as specified by some hash functions. Examples of one-way hash functions are
30 MD5 and SHA, (refer respectively, R. Rivest, "The MD5 message digest algorithm," IETF RFC 1321, April 1992 and National Institute of Standards and Technology, NIST FIPS PUB 186, "Digital Signature Standard," U.S. Department of Commerce, May 1994). Another example of a cryptographic pseudo random

-7-

generator is a strong encryption algorithm such as IDEA with k as the encryption key, v_i as plaintext, and the ciphertext output as the pseudo random sequence.

In the illustrative embodiment for encryption, the segment key s_i is used by the cipher $E()$ to encrypt only one data segment d_i . This implies that only the corresponding ciphertext segment c_i and in some cases part of the corresponding data segment are available to an attacker to cryptanalyze the cipher. One selection criteria for $E()$ is that it should be capable of operating at a high-speed. Another selection criteria for $E()$ is that given the limited amount of ciphertexts and even part of the corresponding data segment under a segment key, the cipher $E()$ should be capable of resisting all known attacks. As a consequence, there is a tradeoff between the size of the data segment and system throughput; the larger the size of a data segment, the higher the throughput. On the other hand, a larger data segment implies that more ciphertexts or plaintexts under a segment key are available to an attacker to cryptanalyze the cipher $E()$. Examples of $E()$ are high-speed stream ciphers or block ciphers with fewer rounds of iterations than that when they are used alone. In the latter case, the notation $E(s_i, d_i)$ represents the encryption of data segment d_i using a block cipher even when the size of the data segment d_i is larger than the block size of the underlying block cipher and the encryption may be performed in various modes, such as Electronic Code Book or Cipher Block Chaining Mode.

One specific example of $E()$ is the following high-speed stream cipher. Let $N()$ be a function defined as $N(s, x) = (((x + s_1) \oplus s_2) \times s_3) \oplus s_4) >>>$, where $s = s_1 s_2 s_3 s_4$ (consisting of four 32-bit strings) is a 128 bit secret key, x is a 32-bit string, \oplus is the bit-wise exclusive-or, $+$ and \times are mod 2^{32} addition and multiplication, and $>>>$ is to reverse a 32 bit string into opposite ranking. Let $b_1 b_2 \Lambda b_m \Lambda$ be the data to be encrypted which is a concatenation of 32 bit strings, the corresponding ciphertexts are given by $d_i = b_i \oplus N(s, N(s, N(s, d_{i-1}) \oplus b_{i-1}) \oplus d_{i-2})$, where the initial values d_{-1}, d_{-2}, d_{-3} can be set to s_2, s_3, s_4 .

Another specific example of $E()$ is Serpent with a reduced number of rounds. Serpent is a block cipher with 128 bit block length, variable key lengths, and 32

-8-

rounds of operations (see R. Anderson, E. Biham, and L. Knudsen, "Serpent: A Proposal for the Advanced Encryption Standard", <http://www.cl.cam.ac.uk/~rja14/serpent.html>). Its inventors showed that to attack 6 round Serpent successfully, it would require 2^{56} and 2^{116} plaintext blocks using linear and differential cryptanalysis, respectively. Hence, if a 6 round Serpent is used as $E()$ to encrypt data, it should resist both linear and differential cryptanalysis as long as the data segment size is less than 2^{56} 128 bit blocks. At the same time, this $E()$ is about 5 times faster than the 32 round Serpent.

10 FIGURE 2 depicts a flowchart of the operation of the present invention at the data decrypting end of a communication channel. As shown in FIGURE 2, at step 200, a program at the decrypting end accepts the shared secret key k and the shared initial value v_0 as inputs, and sets the index $i = 0$.

15 The program then checks at 210 to see if there is any ciphertext segment available for decryption and if not, the program halts its operation. Assuming that a ciphertext segment is received, the program, at 220, increments the index i by 1, updates the initial value $v_i = F(v_{i-1})$, computes a segment key $s_i = R(k, v_i)$, and uses the segment key to decrypt the ciphertext segment to get the data segment $d_i = D(s_i, c_i)$ in a fashion that is well known in the art.

As shown at 230, the program preferably outputs the data segment and then goes back to 210 to see if there is more ciphertext segment available for decryption. If so, the preceding steps are repeated.

25 The embodiment described above is merely one illustrative example of realizing the present invention; there can be many variants of this. For example, it is well within the capability of persons skilled in the art to suggest alternative ways of generating segment keys using a pseudo random generator, where the current segment key may depend not only on the cryptographic key k , but also on other variables such as part of the plaintext, part of the ciphertext, a time stamp, and previous segment keys.

Finally, it is to be understood that various alterations, modifications and/or additions may be introduced into the constructions and arrangements of parts previously described without departing from the spirit or ambit of the present invention.

CLAIMS

1. A method of encrypting data suitable for sending to a decrypting party, said
5 method including the steps of:
- (a) dividing said data into data segments;
 - (b) accepting at least a cryptographic key k shared with the decrypting party;
 - (c) for the i th data segment ($i = 1, 2, \dots$) to be encrypted, generating
10 the i th segment key s_i using a first function with said cryptographic key k and some accessory data strings as inputs;
 - (d) encrypting the i th data segment using a second function with s_i as the encryption key to form the i th ciphertext segment; and
 - (e) outputting the i th ciphertext segment, and at least a part of said
15 accessory data strings for sending data to the decrypting party, and if more data segments are to be encrypted, repeating steps (c), (d) and (e).
2. A method according to claim 1 wherein said accessory data strings include
20 a single string v_i derived from the previous value v_{i-1} in a predetermined fashion.
3. A method according to claim 2 wherein said string v_i is derived according to the relation $v_i = F(v_{i-1})$, $i = 1, 2, \dots$, wherein $F()$ maps v_{i-1} to v_i and v_0 is an initialization value made known to the decrypting party.
25
4. A method according to claim 1, 2 or 3 wherein step (e) includes outputting the size of the corresponding data segment.
5. A method according to any one of the preceding claims wherein said first
30 function includes a cryptographic pseudo random generator.
6. A method according to claim 5 wherein said pseudo random generator includes a keyed hash function $h(k, v_{i1}, v_{i2}, \dots, v_{il})$, wherein k is said cryptographic key, $(v_{i1}, v_{i2}, \dots, v_{il})$ is said accessory data strings and l is a positive integer.

-11-

7. A method according to claim 6 wherein $h()$ is MD5 or SHA.
8. A method according to any one of the preceding claims wherein said
5 accessory data strings are derived from various sources.
9. A method according to claim 8 wherein said sources include current time
and date, or previous accessory data strings, or some initialization values, or at
least a part of the data segments or previous ciphertext segments, or at least a
10 part of previous segment keys.
10. A method according to claim 1 wherein said accessory data strings include
two parts, one part being derived by the decrypting party in a predetermined
fashion prior to decrypting said i th ciphertext segment and the other part not being
15 derived by, and therefore being sent to, the decrypting party prior to decrypting
said i th ciphertext segment.
11. A method according to any one of the preceding claims wherein said
second function includes an encryption function of a symmetric key cipher.
20
12. A method according to any one of claims 1 to 10 wherein said second
function includes an encryption function of a block cipher operating in a well
known mode, such as Electronic Code Book mode.
- 25 13. A method according to any one of claims 1 to 10 wherein said second
function includes an encryption function resulting from combined use of more
than one symmetric key cipher.
14. A method of decrypting data encrypted by an encrypting party, said
30 method including the steps of:
- (a) accepting at least a cryptographic key k being shared with the
encrypting party;

-12-

- (b) for the i th ciphertext segment ($i = 1, 2, \dots$) to be decrypted, generating the i th segment key s_i using a first function with said cryptographic key k and some accessory data strings as inputs;
- (c) decrypting the i th ciphertext segment using a second function with s_i as the decryption key;
- (d) outputting the decrypted i th ciphertext segment, and if more ciphertext segments are to be decrypted, repeating steps (b), (c) and (d).
- 10 15. A method according to claim 14 wherein said accessory data strings include a single string v_i derived from the previous value v_{i-1} in a predetermined fashion.
- 15 16. A method according to claim 15 wherein said string v_i is derived according to the relation $v_i = F(v_{i-1})$, $i = 1, 2, \dots$, wherein $F()$ maps v_{i-1} to v_i and v_0 is an initialization value made known to the encrypting party.
17. A method according to claim 14, 15 or 16 wherein said first function includes a cryptographic pseudo random generator.
- 20 18. A method according to claim 17 wherein said pseudo random generator includes a keyed hash function $h(k, v_{i1}, v_{i2}, \dots, v_{il})$, wherein k is said cryptographic key, $(v_{i1}, v_{i2}, \dots, v_{il})$ is said accessory data strings and l is a positive integer.
- 25 19. A method according to claim 18 wherein $h()$ is MD5 or SHA.
20. A method according to any one of claims 14 to 19 wherein said accessory data strings include two parts, one part being derived by the decrypting party in a predetermined fashion from available sources prior to decrypting said i th ciphertext segment and the other part not being derived by, and therefore being received by, the decrypting party prior to decrypting said i th ciphertext segment.
- 30 21. A method according to any one of claims 14 to 20 wherein said second function includes a decryption function of a symmetric key cipher.

-13-

22. A method according to any one of claims 14 to 20 wherein said second function includes a decryption function of a block cipher operating in a well known mode, such as Electronic Code Book mode.

5

23. A method according to any one of claims 14 to 20 wherein said second function includes a decryption function resulting from a combined use of more than one symmetric key cipher.

10

24. Apparatus for encrypting data suitable for sending to a decrypting party, said apparatus including:

(a) means for dividing said data into data segments;

(b) means for accepting at least a cryptographic key k shared with the decrypting party;

15

(c) means for generating for the i th data segment ($i = 1, 2, \dots$) to be encrypted, the i th segment key s_i using a first function with said cryptographic key k and some accessory data strings as inputs;

(d) means for encrypting the i th data segment using a second function with s_i as the encryption key to form the i th ciphertext segment; and

20

(e) means for outputting the i th ciphertext segment, and at least a part of said accessory data strings for sending data to the decrypting party.

25. Apparatus according to claim 24 wherein said accessory data strings include a single string v_i derived from the previous value v_{i-1} in a predetermined fashion.

26. Apparatus according to claim 25 wherein said string v_i is derived according to the relation $v_i = F(v_{i-1})$, $i = 1, 2, \dots$, wherein $F()$ maps v_{i-1} to v_i and v_0 is an initialization value made known to the decrypting party.

30

27. Apparatus according to claim 24, 25 or 26 wherein said means for outputting is adapted for outputting the size of the corresponding data segment.

-14-

28. Apparatus according to any one of claims 24 to 27 wherein said first function includes a cryptographic pseudo random generator.
29. Apparatus according to claim 28 wherein said pseudo random generator
5 includes a keyed hash function $h(k, v_{i1}, v_{i2}, \dots, v_{il})$, wherein k is said cryptographic key, $(v_{i1}, v_{i2}, \dots, v_{il})$ is said accessory data strings and l is a positive integer.
30. Apparatus according to claim 29 wherein $h()$ is MD5 or SHA.
- 10 31. Apparatus according to any one of claims 24 to 29 wherein said accessory data strings are derived from various sources.
32. Apparatus according to claim 31 wherein said sources include current time and date, or previous accessory data strings, or some initialization values, or at
15 least a part of the data segments or previous ciphertext segments, or a part of previous segment keys.
33. Apparatus according to claim 24 wherein said accessory data strings include two parts, one part being derived by the decrypting party in a
20 predetermined fashion prior to decrypting said i th ciphertext segment and the other part not being derived by, and therefore being sent to, the decrypting party prior to decrypting said i th ciphertext segment.
34. Apparatus according to any one of claims 24 to 33 wherein said second
25 function includes an encryption function of a symmetric key cipher.
35. Apparatus according to any one of claims 24 to 33 wherein said second function includes an encryption function of a block cipher operating in a well known mode, such as Electronic Code Book mode.
30
36. Apparatus according to any one of claims 24 to 33 wherein said second function includes an encryption function resulting from combined use of more than one symmetric key cipher.

-15-

37. Apparatus for decrypting data encrypted by an encrypting party, said apparatus including:

- (a) means for accepting at least a cryptographic key k being shared with the encrypting party;
- 5 (b) means for generating as inputs for the i th ciphertext segment ($i = 1, 2, \dots$) to be decrypted, the i th segment key s_i using a first function with said cryptographic key k and some accessory data strings;
- (c) means for decrypting the i th ciphertext segment using a second function with s_i as the decryption key; and
- 10 (d) means for outputting the decrypted i th ciphertext segment.

38. Apparatus according to claim 37 wherein said accessory data strings include a single string v_i derived from the previous value v_{i-1} in a predetermined fashion.

15

39. Apparatus according to claim 38 wherein said string v_i is derived according to the relation $v_i = F(v_{i-1})$, $i = 1, 2, \dots$, wherein $F()$ maps v_{i-1} to v_i and v_0 is an initialization value made known to the encrypting party.

20 40. Apparatus according to claim 37, 38 or 39 wherein said first function includes a cryptographic pseudo random generator.

41. Apparatus according to claim 40 wherein said pseudo random generator includes a keyed hash function $h(k, v_{i1}, v_{i2}, \dots, v_{il})$, wherein k is said cryptographic
25 key, $(v_{i1}, v_{i2}, \dots, v_{il})$ is said accessory data strings and l is a positive integer.

42. Apparatus according to claim 41 wherein $h()$ is MD5 or SHA.

43. Apparatus according to any one of claims 37 to 42 wherein said accessory
30 data strings include two parts, one part being derived by the decrypting party in a predetermined fashion from available sources prior to decrypting said i th ciphertext segment and the other part not being derived by, and therefore being received by, the decrypting party prior to decrypting said i th ciphertext segment.

-16-

44. Apparatus according to any one of claims 37 to 43 wherein said second function includes a decryption function of a symmetric key cipher.

45. Apparatus according to any one of claims 37 to 43 wherein said second
5 function includes a decryption function of a block cipher operating in a well known mode, such as Electronic Code Book mode.

46. Apparatus according to any one of claims 37 to 43 wherein said second
10 function includes a decryption function resulting from a combined use of more than one symmetric key cipher.

1/2

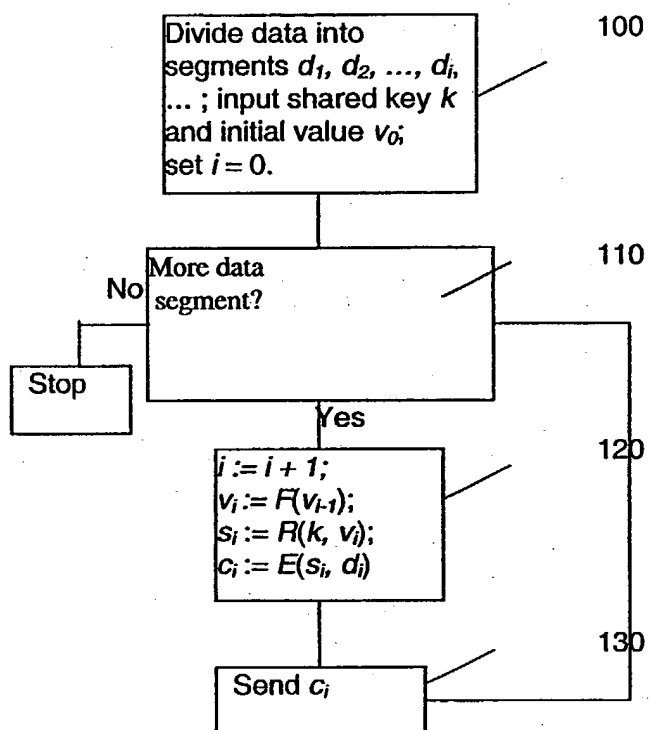
DRAWINGS

FIGURE 1

2/2

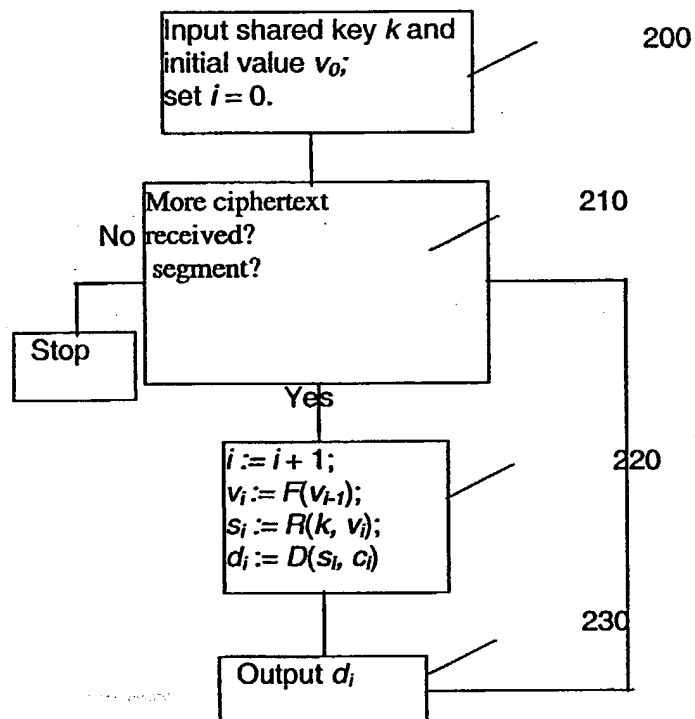


FIGURE 2

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SG 99/00020

CLASSIFICATION OF SUBJECT MATTER

IPC⁷: H 04 L 9/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC⁷: H 04 L; H 04 N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WPI, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0676876 A1 (INTERNATIONAL BUSINESS MACHINES CORPORATION) 11 October 1995 (11.10.95) abstract; page 3, line 33 - page 4, line 22; page 4, line 53 - page 5, line 8; fig. 1-4,6	1,14,24,37
A	WO 96/08912 A2 (TITAN INFORMATIONS SYSTEMS) 21 March 1996 (21.03.96) abstract; page 7, line 1 - page 11, line 15; fig. 1-3	1,14,24,37
A	US 5664016 A (PRENEEL et al.) 2 September 1997 (02.09.97) column 2, lines 54-67; column 6, lines 47-60; fig. 5.	1,5,6,24,28,29
A	JP 10-178421 A (TOSHIBA). Patent abstracts of Japan, Vol. 98, No. 11, 30 September 1998 (30.09.98)	1,24

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents:

„A“ document defining the general state of the art which is not considered to be of particular relevance

„E“ earlier application or patent but published on or after the international filing date

„L“ document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

„O“ document referring to an oral disclosure, use, exhibition or other means

„P“ document published prior to the international filing date but later than the priority date claimed

„T“ later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

„X“ document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

„Y“ document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

„&“ document member of the same patent family

Date of the actual completion of the international search

21 August 2000 (21.08.2000)

Date of mailing of the international search report

23 August 2000 (23.08.2000)

Name and mailing address of the ISA/AT

Austrian Patent Office

Kohlmarkt 8-10; A-1014 Vienna

Facsimile No. 1/53424/535

Authorized officer

Hajos

Telephone No. 1/53424/410

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/SG 99/00020

Patent document cited in search report			Publication date	Patent family member(s)		Publication date	
EP	A1	676876	11-10-1995	GB	A0	9406613	08-06-1994
				GB	A1	2288519	13-10-1995
				JP	A2	7281596	27-10-1995
				US	A	5548648	20-08-1996
JP	A2	10178421	30-06-1998	none			
US	A	5664016	02-09-1997	none			
WO	A2	9608912	21-03-1996	AU	A1	44619/96	29-03-1996
WO	A3	9608912	06-06-1996	CA	AA	2199526	21-03-1996
				EP	A1	787391	06-08-1997
				EP	A4	787391	08-04-1998
				US	A	5796829	18-08-1998